

REMARKS

Applicant respectfully requests reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow.

In the specification, paragraph 1 on page 1 has been amended. No new matter is added.

Claims 1-4, 6-8, 10, 11, 17 and 18 are currently being amended. No new matter is added.

This amendment changes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, is presented, with an appropriate defined status identifier.

After amending the claims as set forth above, claims 1-23 are now pending in this application.

In Paragraph 1 of the Office Action, the Examiner has objected to the Specification for informalities. Applicants have amended paragraph 1 of the application in accordance with the Examiner's suggestion. Withdrawal of the objection to the disclosure is respectfully requested.

In Paragraph 2 of the Office Action, Claims 1 and 17 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,030,895 ("Joshi"). The Examiner states:

Regarding Claim 1, Joshi et al. disclose a method for fabricating an interconnection structure used on a device in an integrated circuit wherein a barrier layer (34,40) (Figure 2) (Col. 4, lines 50 – 62) is formed along the lateral sidewalls and bottom of a via aperture, where the via aperture is configured to receive a via material that connects a first and second conductive layer. Joshi et al. further disclose that the via material is subsequently deposited (Col. 8, lines 5 – 8) and comprises a ternary Cu alloy (Col. 8, lines 24 – 27).

Applicants respectfully traverse rejection.

In Paragraphs 6-8 of the Office Action, Claims 2-5 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Joshi in view of U.S. Patent No. 6,090,170 (“Andricacos”). The Examiner states:

Regarding Claims 2 and 3, Joshi et al. do not explicitly disclose that the resistance is lowered with copper alloys, but Andricacos et al. disclose (Col. 8, lines 43 – 54) that low resistivity (resistance) is obtained with ternary copper alloys containing In, C, or Sn. Hence, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine Andricacos et al. with Joshi et al. to obtain low resistance Cu alloy conductive regions.

Applicants respectfully traverse the rejection.

In Paragraph 9 of the Office Action, Claims 6-9 are rejected under 35 U.S.C. § 103 over Joshi in view of Cunningham, “Improving Copper Interconnects: A Search for Useful Dopants,” Semiconductor International, April 2000, pp. 1-8 (“Cunningham”), and U.S. Patent No. 5,243,222 (“Harper”). The Examiner states:

Claims 6 – 9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Joshi et al., as applied to Claim 1 and 17 above, and further in view of Cunningham (“Improving Copper Interconnects: A Search for Useful Dopants,” Semiconductor International, April 2000, pp. 1 – 8), and Harper et al. (US 5,243,222).

Applicants respectfully traverse the rejection.

In Paragraph 10 of the Office Action, Claim 10 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Joshi in view of Cunningham. In Paragraph 11 of the Office Action, Claims 11-13 are rejected as being unpatentable over (U.S. Patent No. 6,339,496 Edelstein) in view of Cunningham and further in view of Andricacos. In Paragraph 12 of the Office Action, claims 14-16 are rejected under Joshi in view of Cunningham and further in view of Harper. In Paragraph 13 of the Office Action, Claims 8-20 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Joshi in view of Edelstein.

Applicants respectfully traverse the rejection.

In Paragraph 18 of the Office Action, Claims 21-23 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Edelstein in view of Cunningham. The cited art is referred to below as Joshi, Cunningham, Andricacos, and Edelstein.

To advance prosecution, Applicants have amended independent claims 1, 10 and 17 to recite particular alloy materials. The alloy material includes copper and one element to obtain a low resistance and one element to achieve a large grain size. For example, Claim 1 recites:

a copper alloy via material in the via aperture to form a via, the copper alloy material including zinc (Zn) or silver (Ag) and at least one element for increasing grain size.

In another example, Claim 10 recites:

the ternary copper alloy including at least one element for lowering resistivity and at least one of Chromium (Cr) or Calcium (Ca).

In yet another example, Claim 17 recites:

a ternary copper alloy via including at least one of the following pairs of elements: Tin and Calcium, Tin and Chromium, Zinc and Chromium, Zinc and Calcium, Silver Chromium, and Silver and Calcium.

Each of these independent claims 1, 10 and 17 provides an advantageous copper alloy that results in an interconnect having low resistance and large grain size.

With respect to Independent Claim 1, an element for reducing grain size and an element for reducing resistance, including chromium or silver is explicitly recited. Applicants note that the element is provided as the via fill material for the copper via. None of the cite art suggests such an interconnect material.

In Edelstein, the large laundry list of alloys relate to the copper seed layer, not to the via material. See Edelstein, Col. 4, lines 31-42. The purpose of these copper alloys for the seed

layer is to provide better adhesion to the diffusion barrier layer and are not related to the advantages of the present invention. It is also noted that Edelstein teaches away from the present invention because it teaches that the copper conductor body utilizes an alloy consisting of C, Cl, N, O and S. See, Edelstein Col. 11, lines 22-25. Indeed, even though Edelstein was aware of the large laundry list of elements that can be used as copper alloys, it failed to provide any suggestion for utilizing the elements explicitly recited in Claim 1 in the copper via material. Accordingly, there is no suggestion in Edelstein to use any of chromium, zinc, calcium or silver in the copper fill material.

Cunningham does not provide anything more than a basic discussion of properties of dopants. There is no discussion of a process for manufacturing a via. In fact, Cunningham even states with regard to the elements used to reduce copper's resistivity that "Interestingly, the three dopants with the least effect on copper's resistivity -- silver, zinc and cadmium have been ignored." Cunningham, page 5. Although Cunningham only provides a suggestion for using a ternary copper alloy, that ternary alloy is Cu-Zn-Ca. See Cunningham, page 7. Cadmium is not calcium or chromium. Indeed, one of ordinary skill in the art utilizing Cunningham to choose a ternary alloy would clearly choose the elements of cadmium and zinc because Cunningham concludes "the industry is encouraged to consider cadmium and zinc as doping elements for copper, offering significant improved electrical migration with only a modest increase in resistivity." Therefore, Cunningham does not provide a suggestion for the use of the alloy of Claim 1 and in fact teaches away from the present invention.

Joshi discloses a ternary alloy of Al-Cu-Ag. There is no suggestion to use Cr, Zn, or Ca.

Andricacos and Harper do not provide any suggestion for zinc, silver, chromium or calcium. Andricacos merely teaches the use of various recipes including C, In, and Sn.

Harper discloses a single alloying element comprised of aluminum or chromium. There is no suggestion in Harper to combine chromium with another element.

It is respectfully submitted that the cited art would motivate one of ordinary skill in the art to produce a via material substantially different to that recited in Claim 1. For example, Cunningham clearly teaches that it is desirable to use silver and tin and Andricacos clearly teaches that it is desirable to use carbon, indium and tin. As discussed above, Edelstein provides a teaching of using alloys in a copper seed layer. Accordingly, one of ordinary skill in the art would use various alloys in a copper seed layer of filled by a copper via material including carbon, indium and tin of Andricacos, or zinc and cadmium of Cunningham, or aluminum and silver of Joshi. This combination would not result in the alloy of Claim 1. Therefore, it is respectfully submitted that Claim 1 and its dependent Claims 2-9 are patentable over the cited art.

Claim 10 recites the use of chromium and calcium in a ternary alloy. As discussed above, there is no suggestion for the use of chromium or calcium in a ternary copper alloy in the cited art. Indeed, a combination of the cited art results in a very different ternary alloy than that recited in Claim 10. Accordingly, Claim 10 and its dependent claims 11-16 are patentable over the cited art.

Claim 17 recites the use of tin and chromium, tin and calcium, zinc and chromium, zinc and calcium, silver and chromium, and silver and calcium. Accordingly, Claim 17 is patentable for the same reasons discussed above with respect to Claim 10. Therefore, Claim 17 and its dependent Claims 18-23 are patentable over the cited art.

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to

Deposit Account No. 06-1447. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 06-1447. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 06-1447.

Respectfully submitted,

Date 11-4-03

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